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Subcarrier Multiplexing System with Built-in Dispersion Reduction

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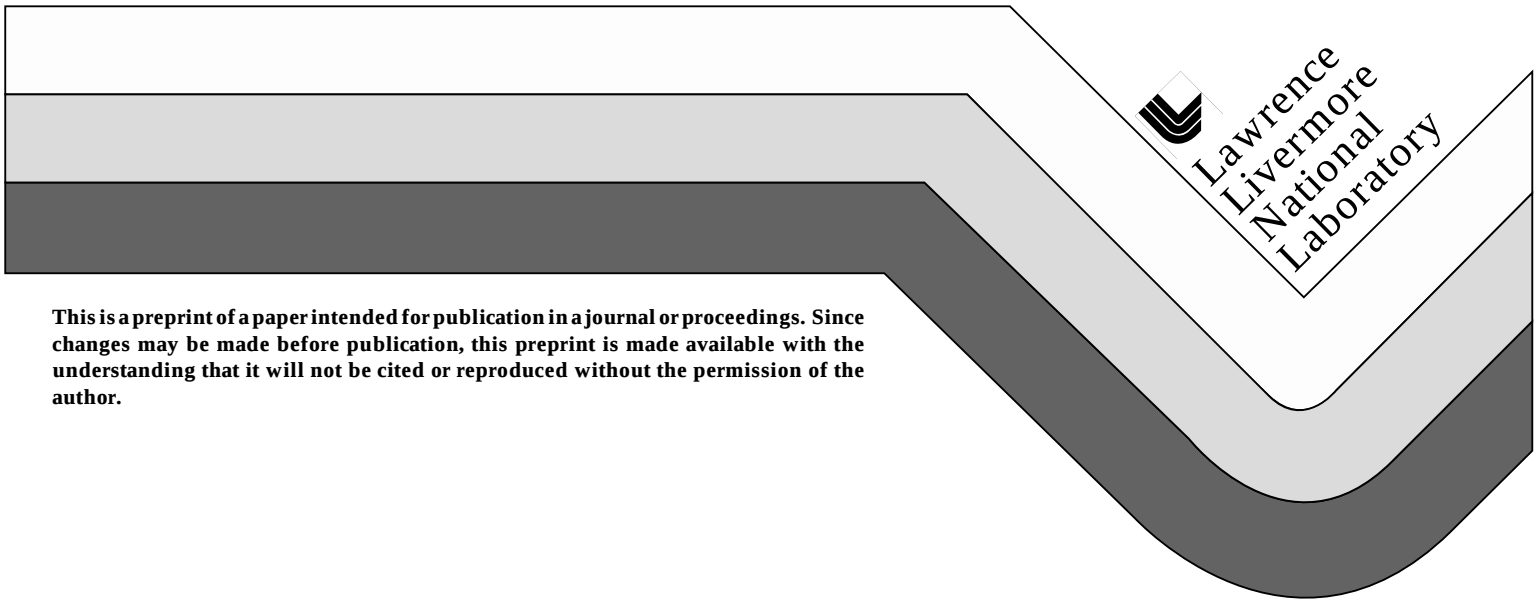

ABSTRACT

Subcarrier multiplexing system with built-in dispersion reduction.

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Dispersion is effectively reduced in a 1550-nm subcarrier-multiplexed fiber link by using optical pre-filtering at the receiver. Recent experimental results demonstrate transmission of two 2.5 Gbit/s data channels over 220 km of ordinary single-mode fiber.

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Experimental high-speed subcarrier multiplexing (SCM) systems presented in the literature to date have used coherent detection schemes[1] which are too complex to implement in a production telecommunications environment. Furthermore, long-haul SCM systems have depended on dispersion-shifted fiber[2]. Our approach allows baseband detection[3] and achieves dispersion reduction in the SCM system. Using commercial microwave mixers and a lithium niobate external modulator, sidebands are generated several gigahertz apart on the principal laser optical carrier. Digital data streams are impressed upon these sidebands for transmission over ordinary single-mode fiber.

A block diagram of our SCM system is shown in Figure 1. Independent 2.5 Gbit/s data streams are upconverted to 7.3 and 14.6 GHz. These microwave subcarriers are then impressed onto a 1550 nm lightwave carrier using an 18-GHz Mach-Zehnder interferometric modulator. To suppress the main optical carrier, the modulator is maintained at null bias. The resulting optical signal traverses 220 km of fiber with the aid of four Erbium-doped fiber amplifiers (EDFAs). Prior to detection, the desired subcarrier is optically pre-selected using a fiber Fabry-Perot (FFP) filter with a bandwidth of 4 GHz and a finesse of 125. The ideal filtered optical spectrum is illustrated in Figure 1, below the block diagram. A 2-GHz bandwidth optical detector converts the selected optical subcarrier back into a baseband electrical 2.5 Gbit/s data stream.

To demonstrate the dispersion reduction effect, the 2.5 Gbit/s repeating pattern (11001010) shown in Figure 2(a) was impressed upon the 14.6 GHz subcarrier. (The 7.3 GHz subcarrier was turned off for this test.) With the FFP filter bypassed, the received pattern in Figure 2(b) was severely distorted due to dispersion. In contrast, when the FFP filter was placed back in line and tuned to the 14.6 GHz subcarrier, Figure 2(c) shows that signal distortion due to chromatic dispersion was practically eliminated.

Using eye diagrams, we evaluated system performance with and without spools of fiber. Pseudorandom bit streams having opposite polarities and different time delays (i.e., uncorrelated data streams) were simultaneously impressed upon the 7.3 and 14.6 GHz channels. To remove dispersion from the experiment without eliminating noise sources, each spool of fiber between the

EDFAs was replaced with an optical attenuator having equivalent loss. Figure 3 (a) and (b) shows a comparison of the eye diagrams that resulted from optically pre-selecting the 7.3 GHz subcarrier with optical attenuators and with fiber, respectively. Figure 3 (c) and (d) shows the same comparison for the 14.6 GHz subcarrier. These results include crosstalk from the other subcarrier channel.

In summary, we have shown how optical pre-filtering can be used in the receiver of a 1550-nm subcarrier multiplexed lightwave system to yield dispersion reduction and baseband detection. We demonstrated the simultaneous transmission of a pair of 2.5 Gbit/s data channels over 220 km of ordinary single-mode fiber with negligible dispersion.

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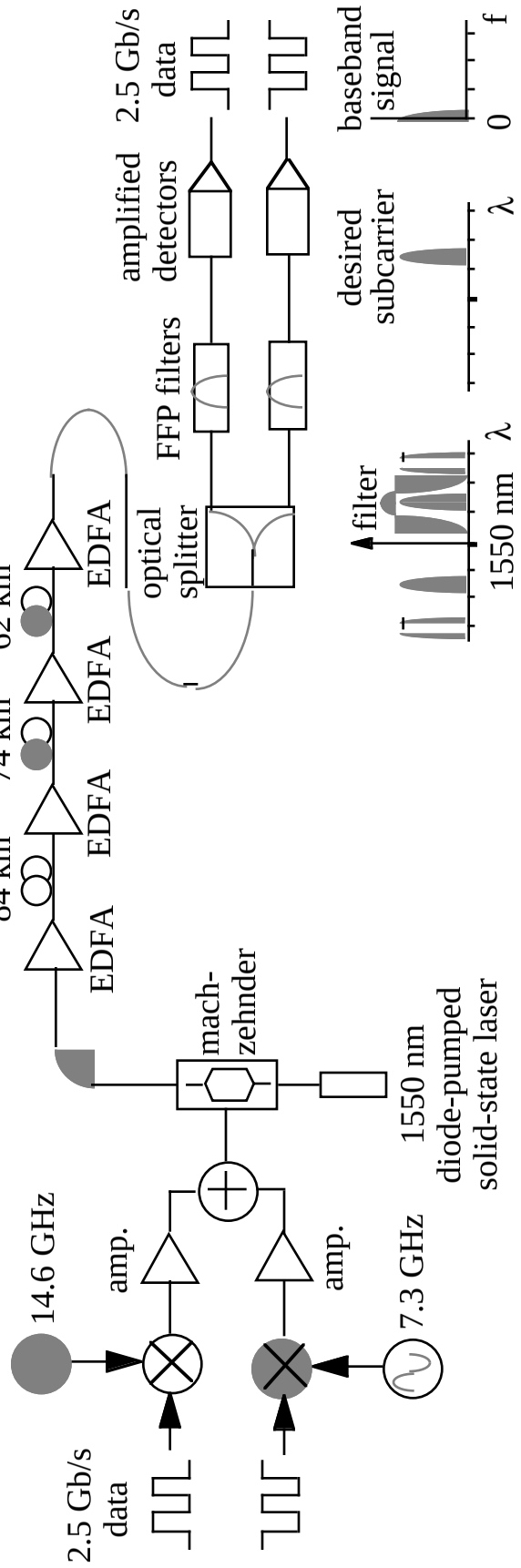

Figure 1. Block diagram of SCM system.

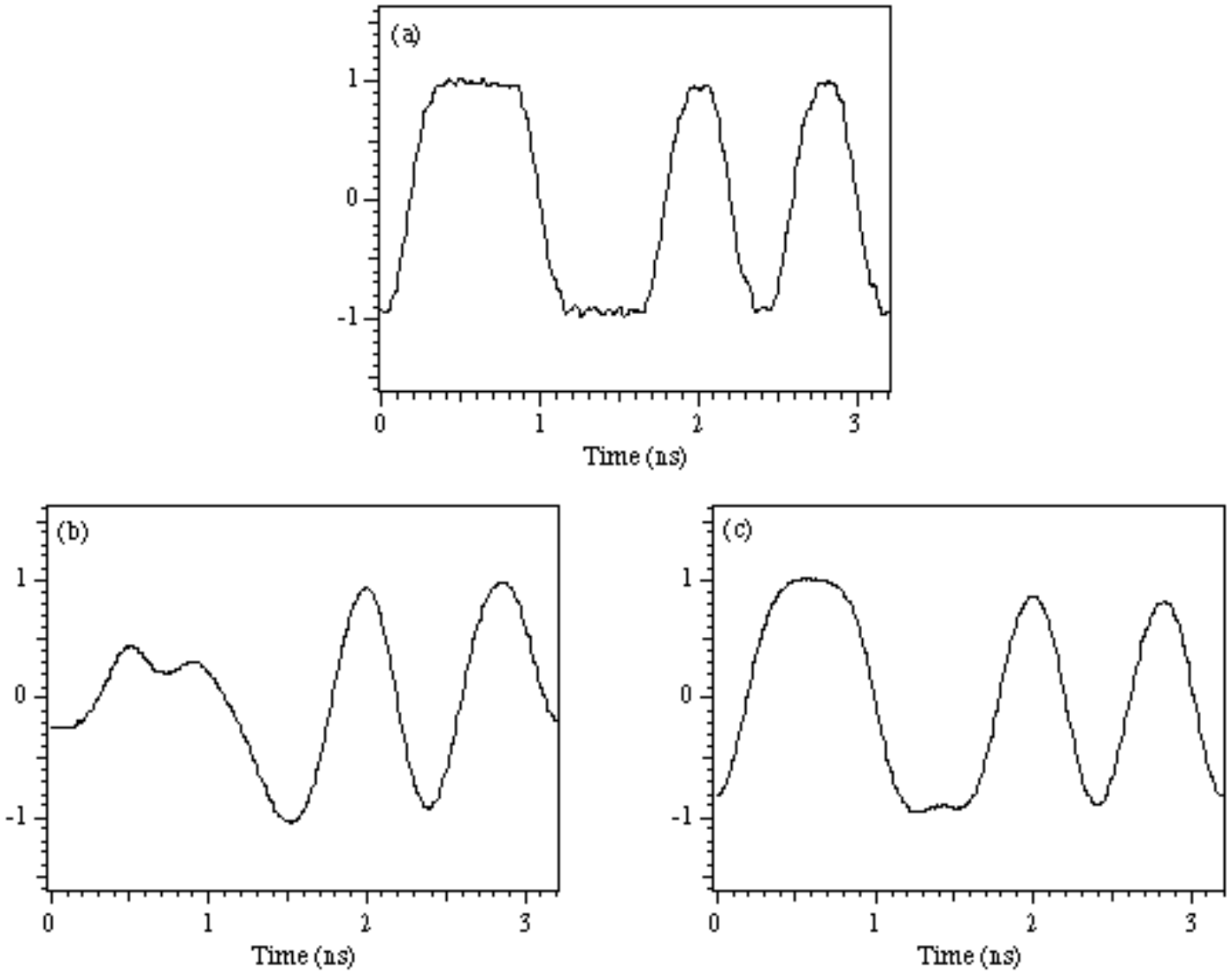

Figure 2. 2.5 Gbit/s data pattern: (a) at input of 14.6 GHz channel, (b) at output without dispersion reduction, (c) at output with dispersion reduction.

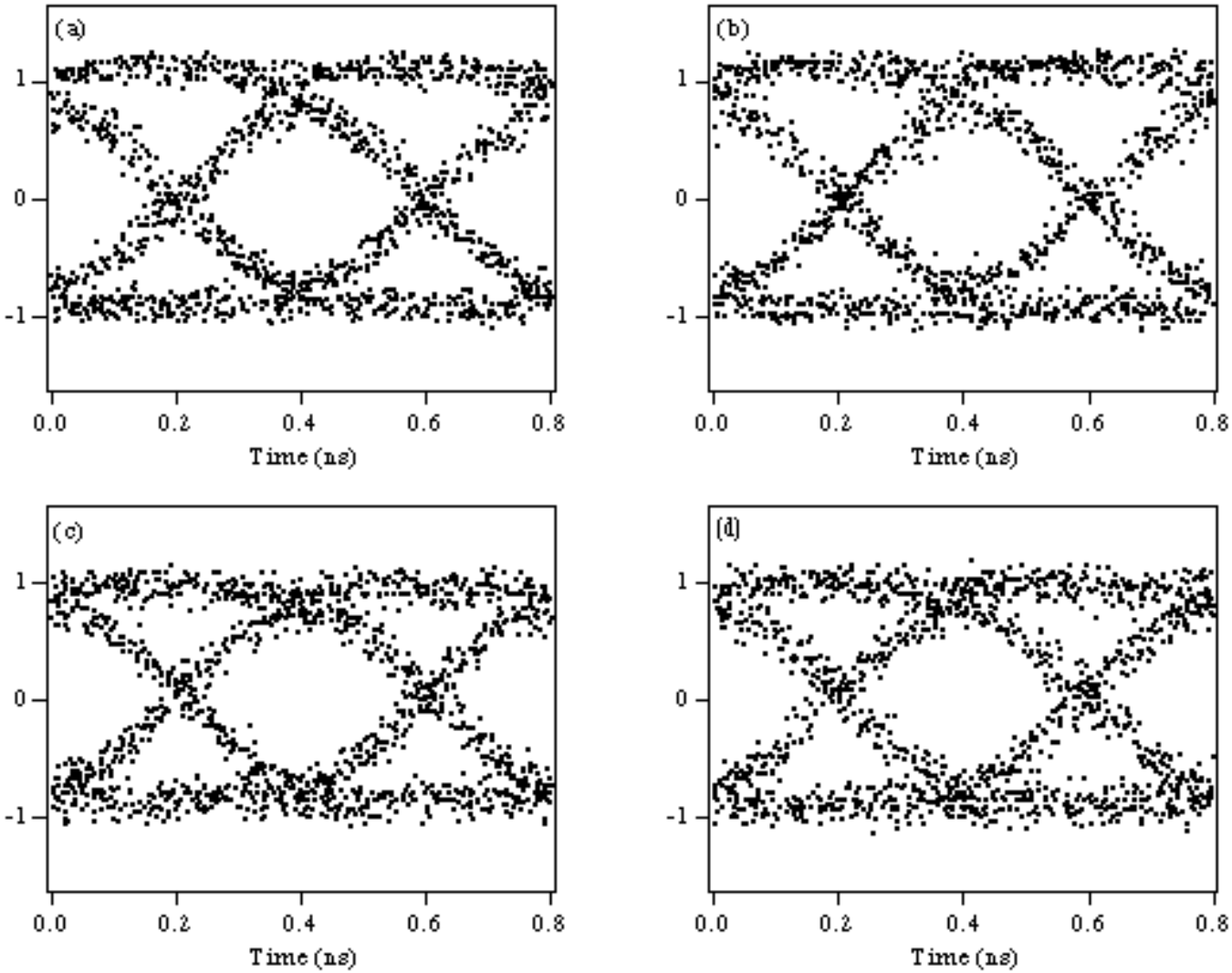

Figure 3. Eye diagrams: (a) 7.3 GHz channel with optical attenuators, (b) 7.3 GHz channel with 220 km of ordinary fiber, (c) 14.6 GHz channel with optical attenuators, (d) 14.6 GHz channel with 220 km of ordinary fiber.

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